

# Physicochemical Characterization of Light Duty Vehicles Exhaust

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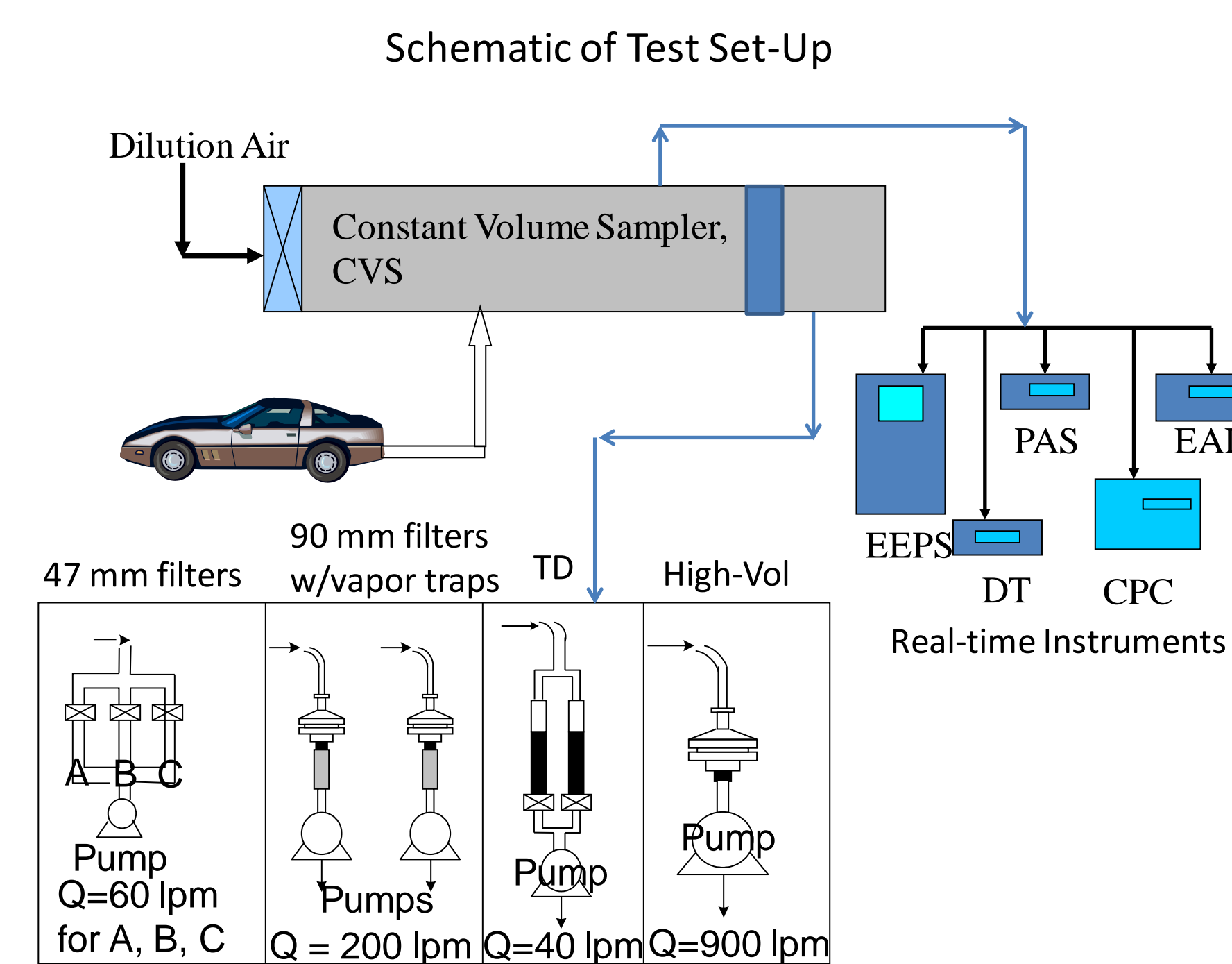


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## OBJECTIVE

As a leading agency in emissions research and regulations, the California Air Resources Board (ARB) has undertaken a program to examine the toxicity of particulate matter (PM) emissions from modern heavy and light-duty vehicles. One of the major thrusts of this program is to determine the toxicity and the physicochemical properties of the semivolatile fraction of PM relative to more refractory (non volatile) PM from vehicular emissions, and to investigate their dependence on the vehicle-engine configuration. Under this program, ARB has tested various heavy-duty diesel engines and compressed natural gas (CNG) buses with advanced aftertreatment control technologies. The current study is continuation of the program and focuses on the light-duty vehicles (LDV).

## MATERIALS AND METHODS

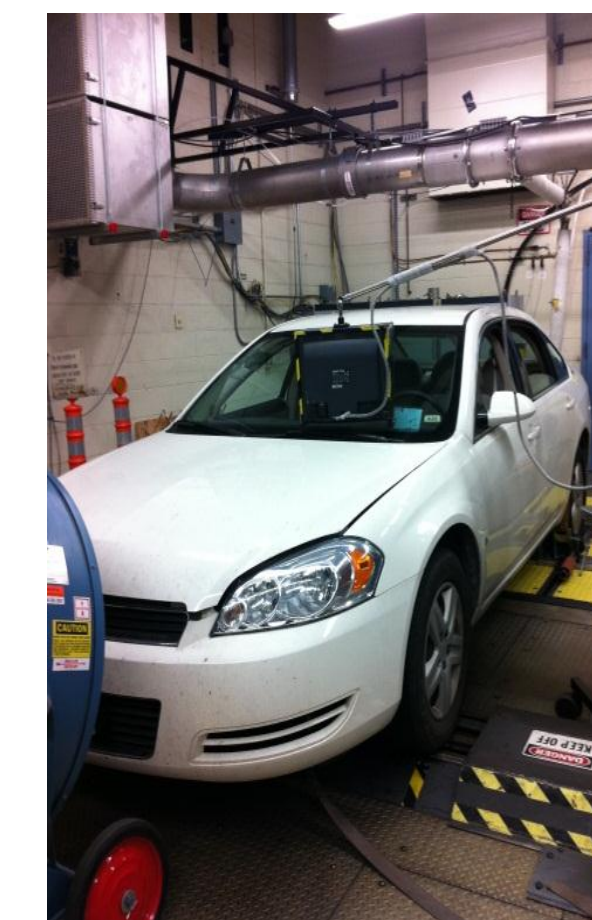


## PROGRESS

To date, five different vehicles have been tested: gasoline port fuel injection (PFI), E-85, CNG, gasoline direct injection (GDI) and GDI with a gasoline particulate filter (GPF). Testing on high-emitter, diesel and biodiesel vehicles will be completed in the coming months. The test vehicles were selected to reflect the current in-use light-duty vehicle fleet and the emerging technologies/fuels which will be commercially available in the California market over the next several years. Each vehicle is tested over the Federal Test Procedure (FTP), transient Unified Cycle (UC) and Highway Cycle (HWY). This presentation provides an overview of selected real-time and chemical data for the first five vehicles tested. The complete review of chemical and toxicity data for all the vehicles will be presented in subsequent conferences.

## LABORATORY SET-UP

Test Vehicles Selection		
Fuel	Technology	Vehicle
Gasoline	PFI	2008 Chevy
E-85	PFI	Impala
CNG	PFI	2007 Honda Civic
Gasoline	GDI	2010 VW
Gasoline	GDI +GPF	Jetta
Gasoline (high-emitter)	PFI	TBD
Diesel	DI	TBD
Biodiesel	DI	TBD



Chassis Dyno



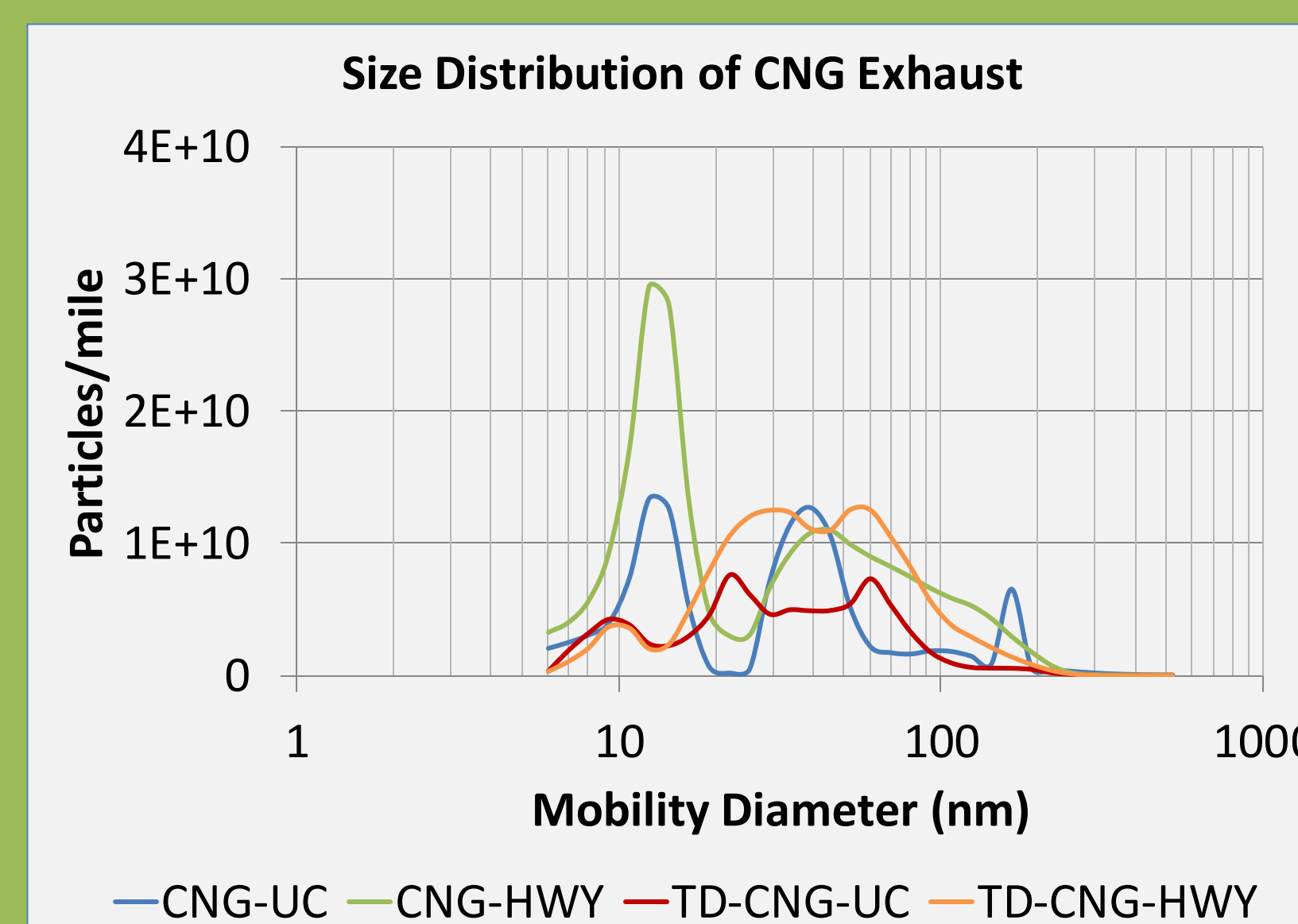
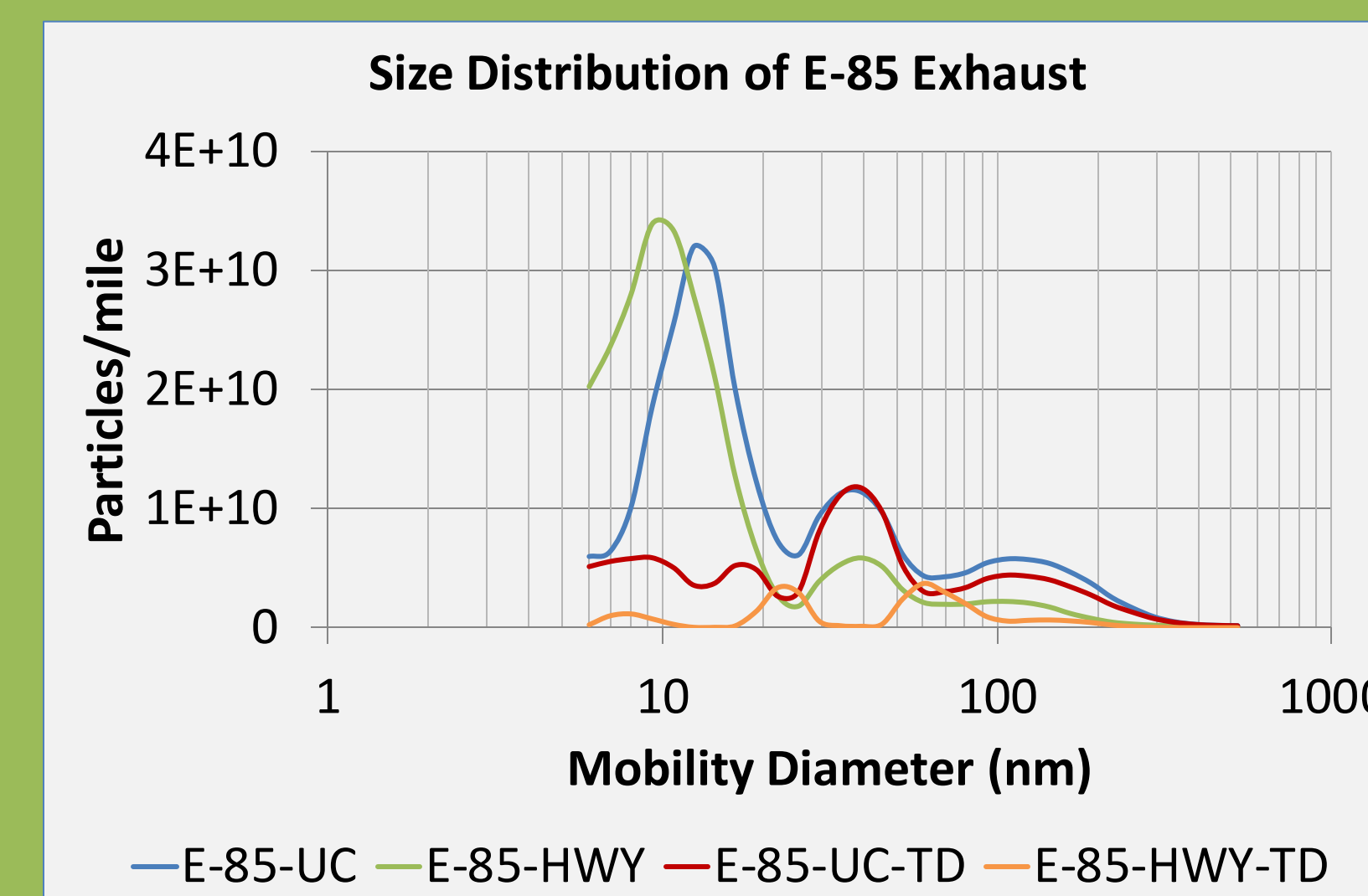
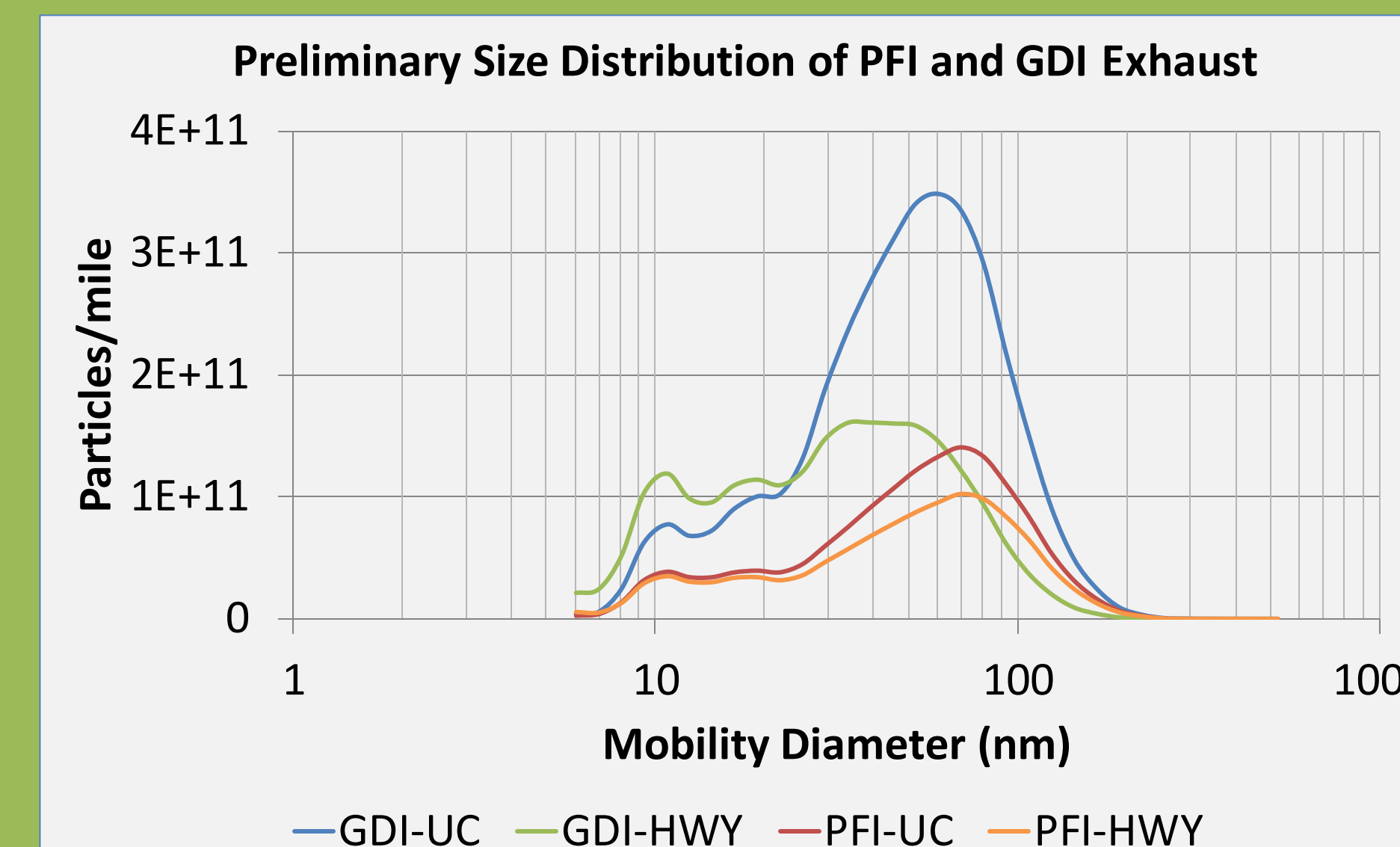
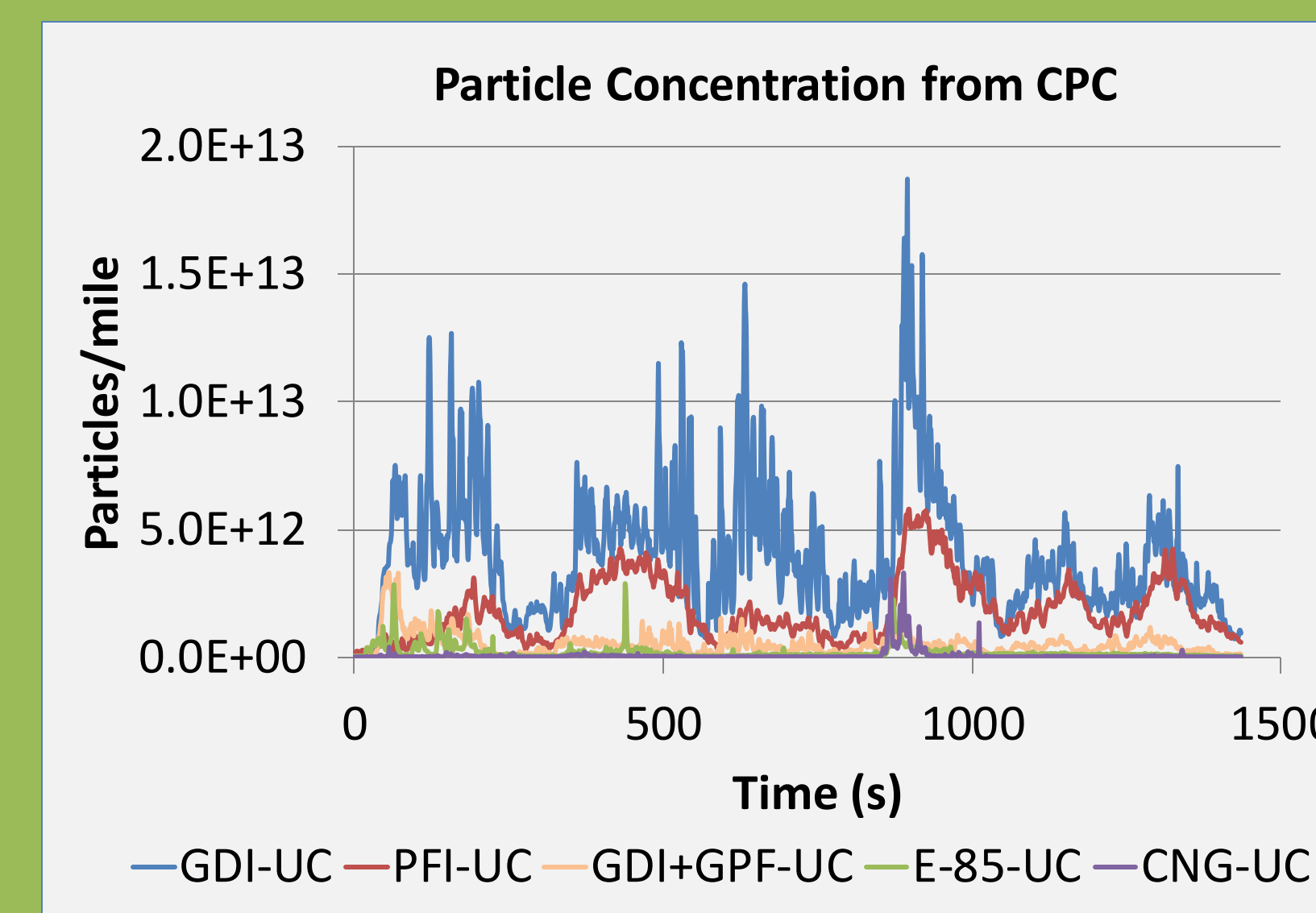
Real-Time Instruments



Hi-Vol/90mm Filters

## RESULTS

### Particle Number and Size Distributions

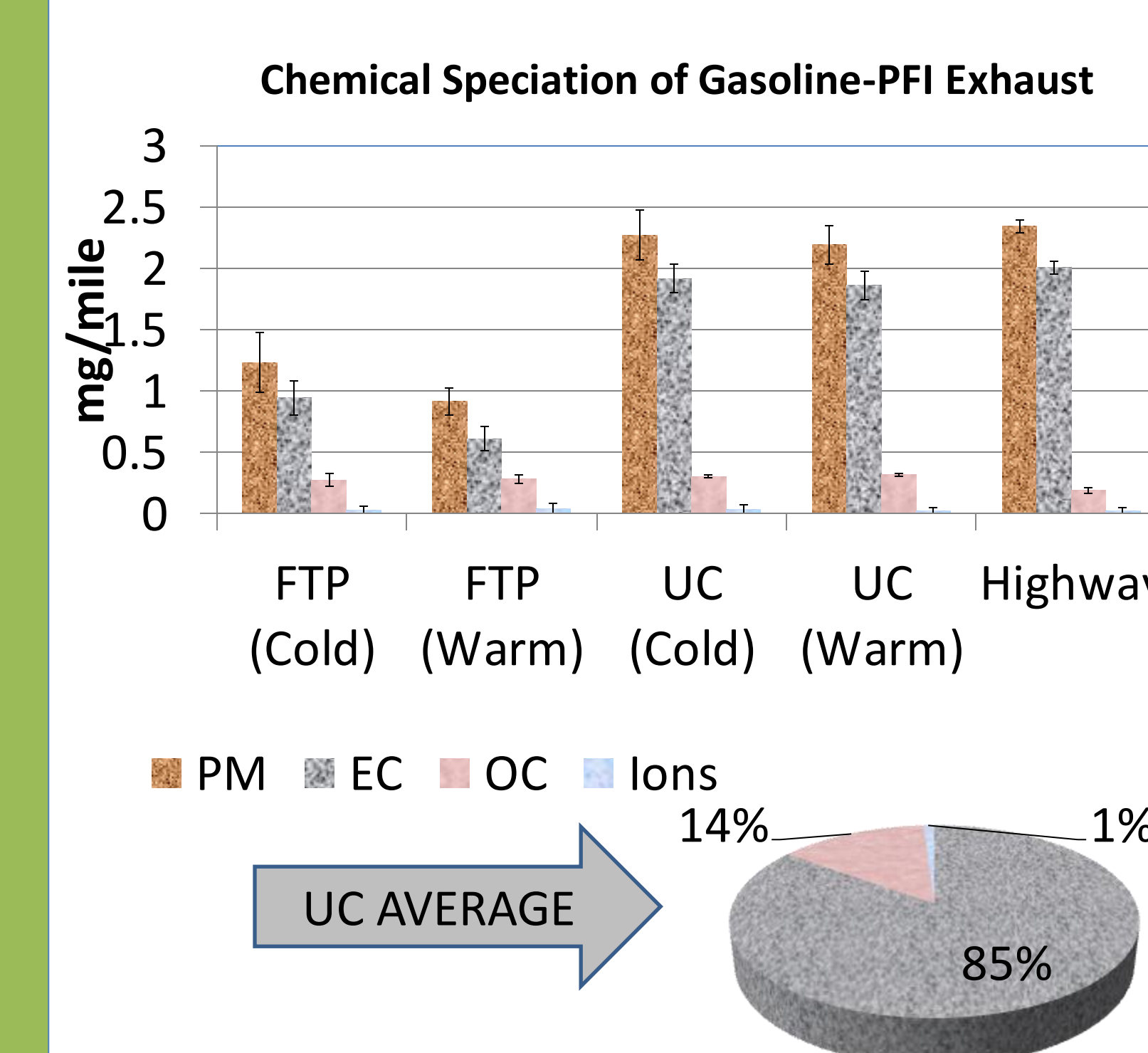
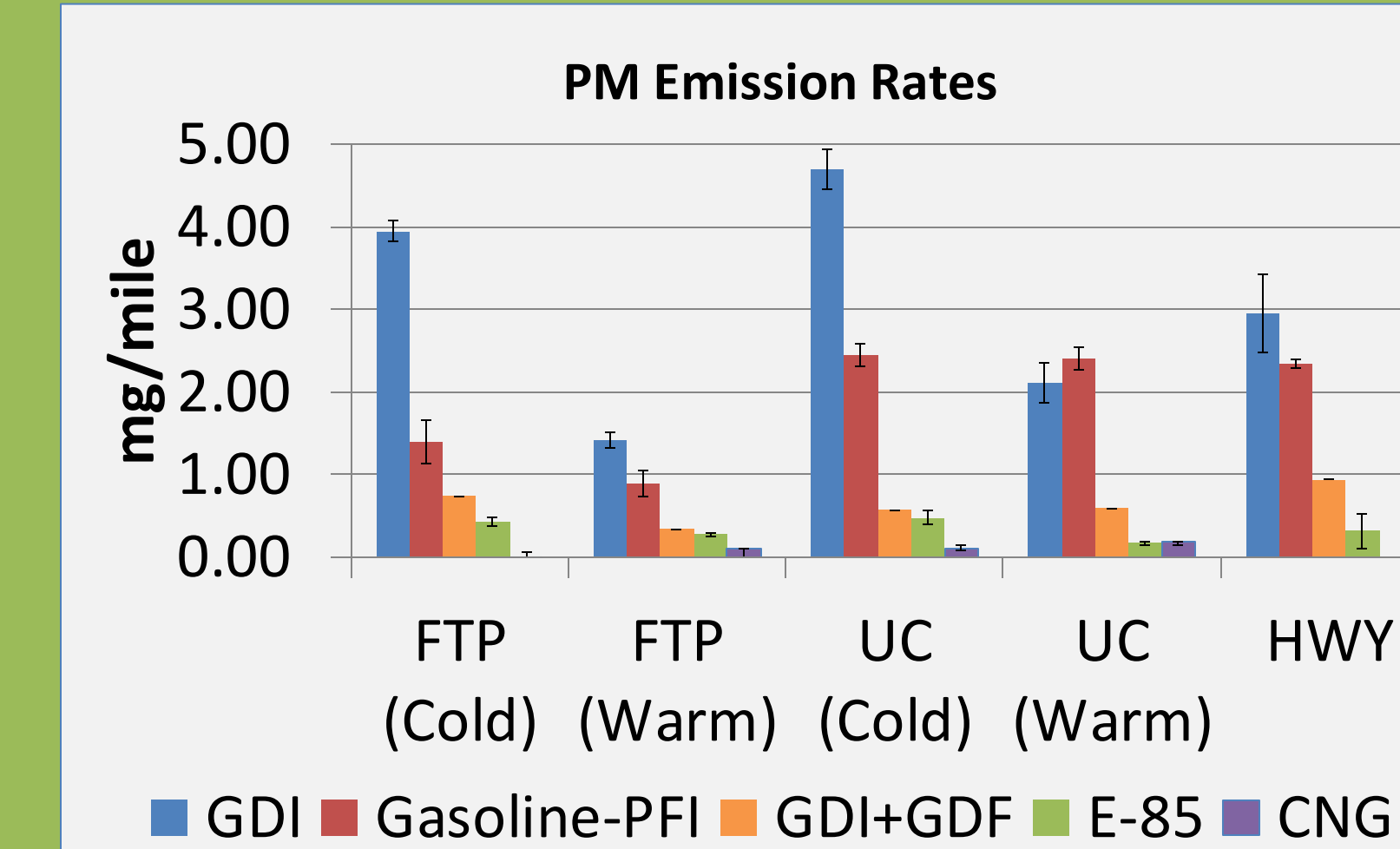


## SUMMARY

- Number emissions measured by the Condensation Particle Counter (CPC) for UC followed this trend:  
GDI > Gasoline PFI > GDI+GPF > E-85 > CNG.
- The number distribution for “clean” fuel vehicles (E-85 and CNG) showed a prominent nucleation mode peak (semi-volatiles) while gasoline vehicles peaked in the accumulation mode (soot PM).
- Thermodenuding (230°C) E-85 and CNG exhaust led to substantial loss in particle numbers-especially in the nucleation mode.

\*TD=Thermodenuded sample using a Dekati Thermodenuder

## Particle Mass and Chemical Speciation



## SUMMARY

- PM Mass Emissions: GDI > Gasoline PFI > GDI+GPF > E-85 > CNG.
- Chemical analysis data showed reduced elemental carbon (EC) formation tendency for oxygenated fuels (E-85) over gasoline -PFI. This is consistent with size distribution data which shows smaller accumulation mode peak (soot PM).
- Data for E-85 showed increased contribution of ions and other unaccounted species towards PM composition. This could be due to increased contribution from lubricating oil emissions as gasoline gets diluted. Awaited metals/elements data could add to the discussion.
- PAS data showed higher polycyclic aromatic hydrocarbons (PAH's) concentration for GDI vehicle (UC) compared to E-85 and CNG vehicles. Reduced PAH's for E-85 reflects lower concentration of aromatics to increase gasoline-alcohol solubility. Cleaner combustion in E-85 and CNG vehicles may also lower PAH's concentration.
- CNG vehicle PM mass emissions were extremely low to negligible. Results (not shown) also indicated adsorption of organic vapors on filter leading to a positive artifact. EC was not detected on the filters.

## ACKNOWLEDGEMENTS

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